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Cancer by County: New Resource for Etiologic Clues

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Abstract. *Mapping of U.S. cancer mortality by county has revealed patterns of etiologic significance. The patterns for bladder cancer in males point to industrial determinants: some are known (chemical manufacturing) but others (automobile and machinery manufacturing) represent new leads for epidemiologic study. By contrast, the geographic clusters of high rates of stomach cancer in both sexes are consistent with ethnic susceptibility.*

Geographic variation in cancer mortality in the United States has usually been evaluated on a state-by-state basis. The paucity of clues to cancer etiology arising from such surveys can be traced to the heterogeneity of statewide populations. Counties may provide a compromise, as units small enough to be homogeneous for demographic and environmental characteristics that might influence cancer risk, and yet large enough for stable estimates of site-specific cancer mortality. We have made some preliminary observations that illustrate the value of county mortality measurements in providing leads to the origins of cancers.

We obtained age-, race-, and sex-specific numbers of cancer deaths for the 3056 counties of the contiguous United States over a 20-year period, 1950–1969, from the National Center for Health Statistics, Rockville, Maryland. Corresponding county populations were provided by the 1950, 1960, and 1970 censuses (*1*), with intercensal estimates derived by linear interpolation. For 35 cancer sites, we calculated age-standardized mortality rates by race and sex in each county, the standard being the age distribution of the entire U.S. population in 1960. Ninety-five percent confidence intervals were computed using the standard error of the age-standardized rate as determined by the method of Chiang (*2*). Differences between the county and national rates were statistically significant when the 95 percent confidence intervals for these rates did not overlap. Tabulations of cancer mortality rates by county were recently compiled (*3*).

Table 1. Industrial categories in which the percentage of men employed in counties where the bladder cancer risk is high differed significantly ($P < .05$) from the percentage of men employed nationwide. See text for method of selecting high-risk counties. Abbreviations: Exp., expected; Obs., observed.

Industry	Percentage of employed men: In the U.S. (Exp.)	Percentage of employed men: In high-risk counties (Obs.)	Obs./Exp.
Agriculture	15.8	4.2	0.3
Mining	2.2	0.3	0.1
Manufacturing	27.0	42.2	1.6
Furniture, lumber, wood	2.7	1.4	0.5
Nonelectrical machinery	2.8	6.3	2.3
Electrical machinery	1.3	2.8	2.2
Motor vehicles	1.9	4.8	2.5

Although population-based mortality data are a crude means of testing hypotheses concerning public health hazards, geographic correlations with environmental measurements can be done quickly and inexpensively, and may be a valuable first step in evaluating possible dangers. In this manner we have assessed cancer mortality patterns among people residing where drinking water is contaminated by asbestos (*4*), where homes are built on radioactive tailings from uranium mines (*5*), and where the chemical industry is highly concentrated (*6*).

The major contribution of the county resource, however, is in hypothesis formulation, namely the detection of geographic clustering that suggests etiologic clues, which can then be pursued by epidemiologic studies of an analytical type. Computer-generated maps were produced to visualize the spatial configuration of cancer mortality by county. We first plotted the distribution for bladder cancer, the tumor most strongly linked to occupational exposures (*7*). In white males there were clusters of elevated mortality in heavily industrialized areas (Fig. 1), a pattern that was not duplicated in females. The clusters in males suggest industrial hazards that should be evaluated.

To further characterize the possible hazards, we selected for correlation analysis a

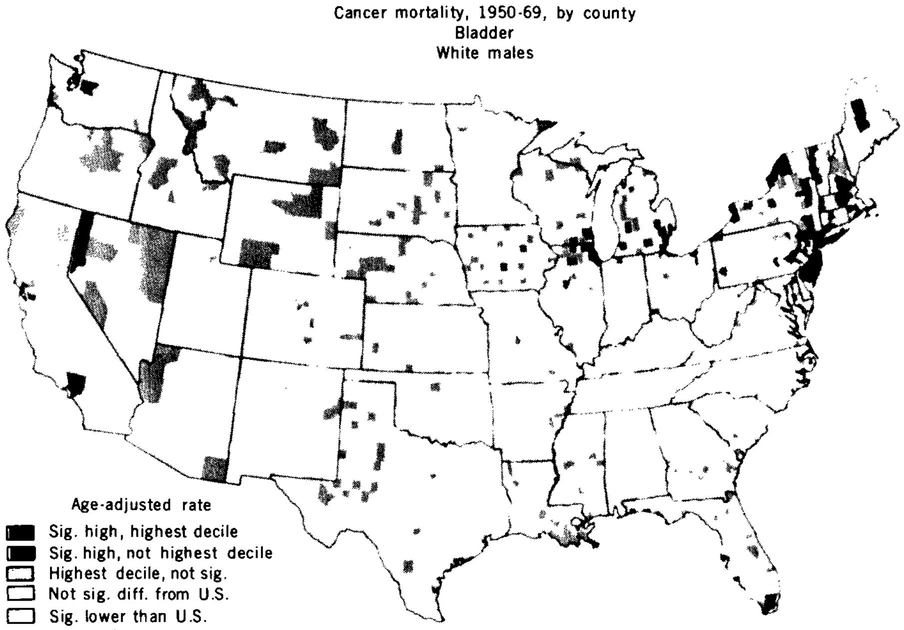

Fig. 1. Mortality from bladder cancer, by county, for white males, 1950–1969.

group of counties with the following criteria: a significantly high mortality from bladder cancer among males when compared with the national rate, a greater male-to-female ratio of bladder cancer than found nationally, and a lung cancer rate among males not significantly different from the national average. While this last stipulation eliminated counties with valuable information, it enabled us to assemble 64 areas where the bladder cancer risk is more likely related to industrial exposure than to cigarette smoking. We determined the industrial makeup of these counties from the 1950 census (*1*), and compared the percentages of workers in 41 separate industries with corresponding percentages for the entire country.

As shown in Table 1, the study counties had a significantly low percentage of workers in three industries, which were mainly concentrated in rural areas, where the risk of bladder cancer is known to be low (*7*). On the other hand, the study counties had a significantly high percentage of workers in three categories: nonelectrical machinery manufacturing, electrical machinery manufacturing, and motor vehicle manufacturing. The study counties are on the average more urban than the United States as a whole. However, overrepresentation of these three industries in the study counties is not simply secondary to an urbanization association. When the study counties were split into two equal groups based on the percentage of the population living in an urban area (percent urban), motor vehicle and nonelectrical machinery manufacturing were overrepresented in both the more rural and the more urban groups. In fact, the association with motor vehicle manufacturing was more impressive in the rural group. In this group (including counties ranging from 0 to 72.5 percent urban, weighted average = 55.5 percent), 7.7 percent of the men employed worked in the automobile industry. Suspicions regarding the automobile industry were deepened by recent results from the Third National Cancer Survey, 1969–1971 (*8*). Detroit had the highest bladder cancer incidence rate (but only the fifth highest lung cancer rate) among white men in the seven cities and two states participating in the survey. Wayne County (Detroit) was excluded from our correlation study on the basis of a significantly elevated lung cancer rate. However, its mortality rate for bladder cancer is significantly high among men but not among women.

Because of the many comparisons involved with data for 3056 counties over 20 years, it may be dangerous to single out a particular county or even a small group of counties for special attention. In certain situations, however, the unusual experience of a county warrants further investigation. For example, Salem County, New Jersey, leads the nation in bladder cancer mortality among white men. We attribute this excess risk to occupational exposures, since about 25 percent of the employed persons in this county work in the chemical industry (*1*), particularly the manufacturing of organic chemicals, which may cause bladder tumors. After the finding was communicated to New Jersey health officials, a company in the area reported that at least 330 workers in a single plant had developed bladder cancer during the last 50 years (*9*). It is urgent that surveys of cancer risk and programs in cancer control be initiated among workers and former workers in this area.

We then selected stomach cancer for mapping, since an earlier analysis failed to reveal the consistently elevated rates previously reported for lower social class communities (*10, 11*). The geographic distribution of stomach cancer mortality for white males is shown in Fig. 2; the pattern for females (not shown) is nearly identical. Elevated mortality is prominent in major cities and in areas characterized by low socioeconomic class (such as certain counties in Pennsylvania and Kentucky). Overshadowing these areas is a cluster of exces-

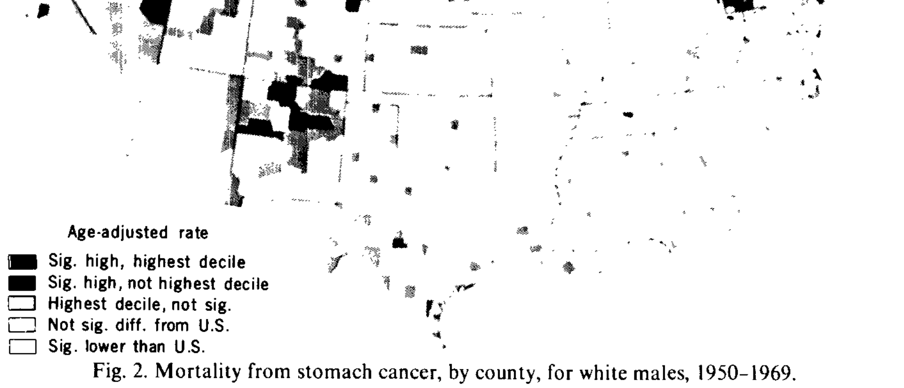

Fig. 2. Mortality from stomach cancer, by county, for white males, 1950–1969.

sive mortality in primarily rural counties in the North Central region (Minnesota, the Dakotas, Michigan, and Wisconsin). Concentrated in these areas are people of Russian, Austrian, Scandinavian, and German descent. In fact, the 306 counties with the highest rates (highest decile) have three times as many first and second generation Finns, Austrians, and Russians as expected, and 40 to 60 percent more Norwegians, Swedes, and Germans than expected on the basis of the national percentages for these ethnic groups (*12*). The possibility that these migrant groups are prone to stomach cancer is compatible with the high incidence of this tumor in their countries of origin (*13, 14*). The smaller cluster in New Mexico and Colorado seems consistent with reports of elevated stomach cancer rates among Spanish-Americans in this area (*15*). Thus, although urbanization and socioeconomic factors affect mortality from stomach cancer, ethnicity seems to be the major determinant of geographic variation within the United States.

A color atlas of U.S. cancer mortality by county for 35 cancer types has recently been published (*16*). For various cancers, the maps reveal a surprising number of clusters or "hot spots." In these areas, physicians, public health officials, county medical societies, occupational health groups, and others concerned with cancer may help to identify previously unrecognized causes of cancer and plan programs in cancer control.

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